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Pictorial Article

Corundum-bearing mafic granulites in the Horoman (Japan) and Ronda (Spain) Peridotite Massifs: Possible remnants of recycled crustal materials in the mantle

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Corundum-bearing mafic granulites (i.e. rocks of high-Al mafic compositions) occur as a minor constituent in several orogenic peridotite massifs of upper mantle origin, for example, Beni Bousera (Morocco; Kornprobst *et al.* 1990), Ronda (Spain; Morishita *et al.* 2001) and Horoman (Japan; Morishita & Arai 2001). Corundum-bearing eclogite xenoliths are also rarely found in kimberlite pipes (e.g. Sobolev *et al.* 1968). Thus, a minor but distinctive high-Al geochemical reservoir may exist in the upper mantle. These rocks generally show geochemical signatures similar to gabbroic rocks of lower crustal origin. From these lines of evidence, corundum-bearing mafic granulites/eclogites are interpreted to be possible remnants of recycled crustal materials in the mantle. The present paper shows the occurrence of corundum-bearing (and associated corundum-free) mafic granulites in the Horoman (Figs 1,2) and Ronda (Figs 3,4) Massifs so as to provide good examples of heterogeneous mantle formed by mixing of recycled crust materials.

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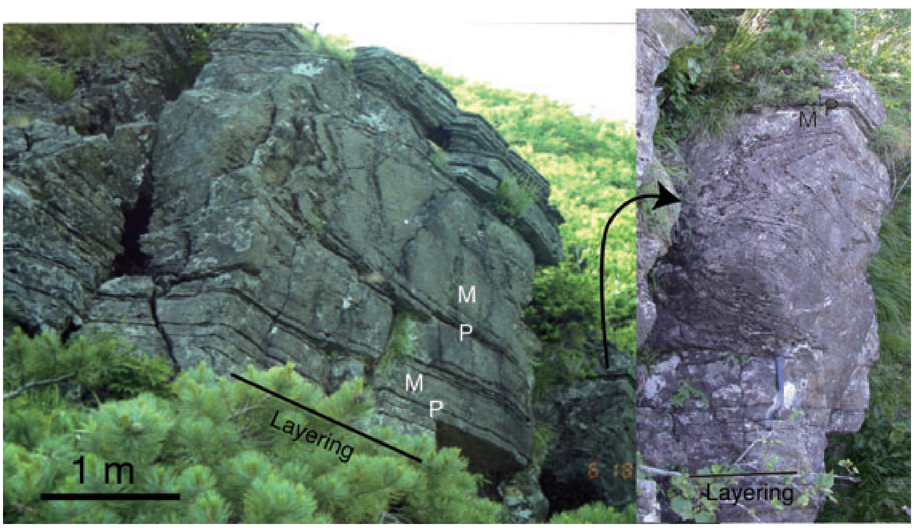

Fig. 1 Occurrence of aluminous mafic granulites (M, corundum-free) associated with peridotites (P) in the Horoman Massif. They usually occur as thin layers (1 cm–2 m thick) alternating with the peridotite layers (P, eroded part). In this outcrop, aluminous mafic granulite is more abundant than peridotite. Aluminous mafic granulite layers occur parallel to the foliation of the peridotites in the upper and lower part of the outcrop. Some layers show isoclinal folding (middle part of the outcrop) as well as boudinage and slump-like structures indicating strong deformation.

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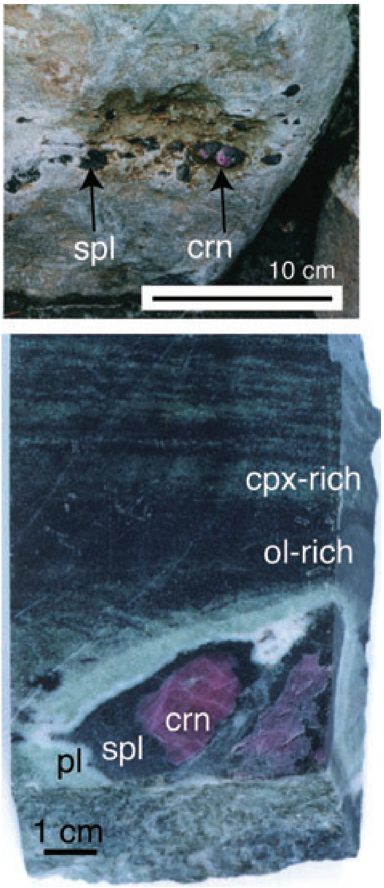

Fig. 2 Pink-colored corundum-bearing mafic granulite in the Horoman Massif (upper panel) and a polished surface of a part of the sample (lower panel) cut parallel to lineation and perpendicular to foliation, defined by mineral alignment. A layered structure consisting of olivine-rich (ol-rich) and clinopyroxene-rich (cpx-rich) sublayers is observed in the corundum-free portion. Corundum and coarse-grained spinel only occur in a relatively thick olivine-poor lenticular portion. The rock, having equigranular metamorphic textures, is completely replaced by later low-pressure mineral assemblages mainly consisting of olivine, plagioclase and clinopyroxene formed during exhumation of the massif except for corundum. A zonal arrangement of inner green spinel (spl) and outer plagioclase (pl) around pink corundum indicates that the corundum was not equilibrated at the last pressure–temperature conditions of the Horoman Massif. As yet, corundum-bearing mafic granulite has only been found as a boulder.

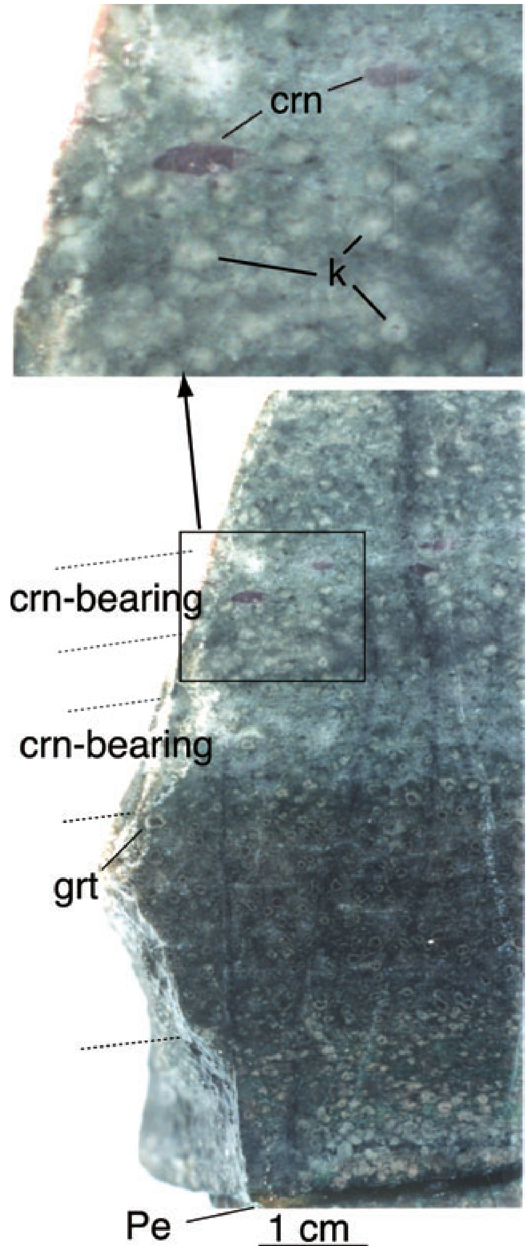

Fig. 3 Polished surface of corundum (crn)-bearing mafic granulites in the Ronda Massif. The rock mainly consists of clinopyroxene, garnet (grt) – now partly to fully replaced by kelyphite (k) – and plagioclase. The sample is divided into several sublayers (indicated by broken lines) corresponding to differences in mineral modes. Two of the sublayers contain corundum grains (up to 5 mm in size, upper panel; crn-bearing). A thin peridotite layer (pe) also exists in the sample. It is interesting to note that geochemical variations among these sublayers are remarkably similar to those of layered gabbros in ophiolites and/or oceanic lithosphere (Morishita *et al.* 2003).

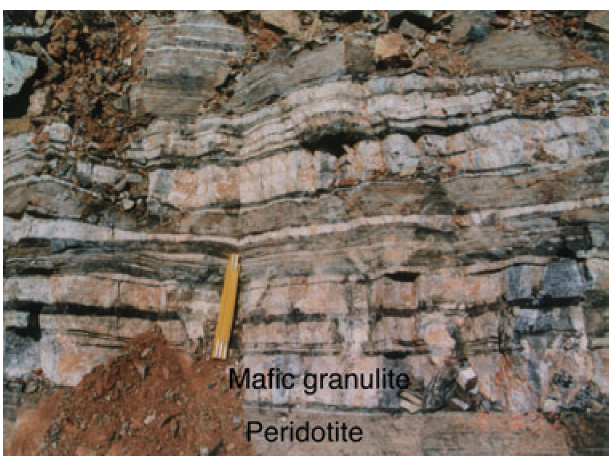

Fig. 4 Occurrence of aluminous mafic granulites (partly corundum-bearing) in the Ronda Massif. Aluminous mafic granulites (white-colored layers) alternate with peridotites (dark to black-colored layers) of a few millimeters to a few tens of centimeters in scale. They are usually parallel to the foliation of the peridotite layers and are frequently boudinaged. Bar, 20 cm.